Circular No. 655

July 1942 • Washington, D. C.

UNITED STATES DEPARTMENT OF AGRICULTURE

Basis for Judging Subalpine Grassland Ranges of Oregon and Washington

By G. D. Pickford, *senior forest ecologist*, and Elbert H. Reid, *assistant range examiner, Pacific Northwest Forest and Range Experiment Station, Forest Service*

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RANGE CONDITION, UTILIZATION STANDARDS, AND PLANT SUCCESSION

The High Importance of Subalpine Grasslands

Subalpine grasslands in the high mountains of eastern Oregon and Washington furnish an important part of the range forage in the Pacific Northwest. These high summer ranges provide succulent weeds and nutritious grasses which enable stockmen to turn off fat lambs and calves. They are most accessible for grazing, and the forage is of highest value, at a season when on the more arid spring and fall ranges vegetation is dry and harsh and water is scarce. Thus these important ranges round out the yearly forage supply for the range livestock of the region.

Use of the mountain ranges of the region for summer grazing only, together with the insufficient quantity of forage, creates an intense demand. In eastern Oregon and Washington, such grazing lands fail by approximately 30 percent to provide sufficient summer forage for the livestock that are grazed in the spring and fall on the sagebrush and Pacific bunchgrass ranges at lower altitudes. This de-

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ficiency results in part from natural causes—much of the land is timber covered and this contributes to a generally low grazing capacity. But to a considerable degree the deficiency is man-caused, being chargeable to forage and soil depletion resulting from too heavy grazing and improper livestock management, conditions accentuated by serious and prolonged droughts.

The manager and the user of these summer ranges, therefore, are faced with the dual problem of supplying forage to the greatest number of livestock the forage will support and at the same time, by conservative grazing practices, increasing the productivity of the range resource.

Subalpine grasslands occupy only about 5 percent of the summer range area of Oregon and Washington, but their potential grazing capacity is estimated to be nearly 20 percent of the total capacity. Among summer-range types, these grasslands, because of abundant water and relatively high quality of forage in comparison with timbered range, have been the most heavily used. The result is serious range depletion. In many instances the type today has no higher per-acre grazing capacity than the timbered range. An increase in grazing capacity through good management is imperative, to aid in securing a better balance between the seasonal range classes and to safeguard more adequately the future stability of the range livestock industry in the region.

The rehabilitation of subalpine grasslands is important also from standpoints other than grazing. Because they hold the headwaters of important streams, these ranges are key areas on which irrigation and water power largely depend. Vegetation-cover disturbances that affect water yield are of serious consequence to these values. Again, because of their proximity to the mountain peaks, these lands command a high summer-recreation value, which is seriously lowered on overgrazed range by accelerated erosion.

On the subalpine grassland ranges the volume of forage production, the number of livestock that may be grazed, and the adequacy of the dependent watershed and recreation services are largely determined by the existing soil and vegetation conditions. In order that a satisfactory condition of the resources may be maintained and further developed, it is important that range-condition trends, particularly if they indicate deterioration, be recognized promptly and correctly interpreted. The lack of definite standards that might serve in interpreting observations or directing conservation measures often causes the early stages of range deterioration to be overlooked, resulting in costly delays in corrective action.

In order to determine what can be used as effective guides in judging the condition of soil and vegetation, thereby to bring about proper management and use of these subalpine grasslands, the Pacific Northwest Forest and Range Experiment Station conducted studies on subalpine grassland areas in eastern Oregon in 1937 and 1938. Two important range types found on subalpine grasslands in eastern Oregon and Washington were involved—the green fescue type and the needlegrass-weed type.

The purpose of this circular is to summarize results of these studies as a basis for judging the condition and use of subalpine grassland range. The characteristics of this range in various condition stages

are presented, as are comparative values for grazing, watershed, and protection of soil from accelerated erosion. Means for field identification of condition stages, trends of range condition, and current proper utilization are also described. It is believed that this circular will be not only of immediate value in the present war emergency to those who graze and manage livestock on subalpine ranges, but also of interest to stockmen elsewhere, to all range managers, and to those who study the development of range vegetation and the characteristics of range soils as influenced by grazing animals.

The Role of Plant Succession in Determining Range Condition

One of the most important questions in setting up standards for utilizing subalpine grassland range is the condition of forage and soil, and whether the trend is toward improvement or deterioration. The studies of plant succession by Clements(*2*),[1] Sampson (*10*), and others are conclusive that vegetation and soil develop interdependently, and that in the subalpine grassland association several well-defined types of vegetation systematically succeed each other coincidently with soil changes.

Sampson identifies four vegetation types or stages that feature plant succession on subalpine grasslands in central Utah, culminating in the highest development possible under the prevailing climate, as follows: (1) Early maturing annuals and weak perennials, growing on gravelly loam poor in organic matter and moderately low in available moisture; (2) perennial herbs, chiefly weeds with some aggressive grasses and shrubs, growing on loamy, slightly gravelly soil containing moderate amounts of organic material and available moisture; (3) aggressive perennial grasses in abundance with perennial herbs and shrubs, growing on loamy, fine gravelly soil moderately high in organic material and available moisture content; (4) deep-rooted or densely tufted perennial grasses, growing almost to the exclusion of other plants on loamy, fine gravelly soil high in organic matter and available moisture. These stages, termed the first weed, second weed, mixed grass-and-weed, and climax, have been widely checked on subalpine grasslands by numerous workers, and the validity of this classification has been generally accepted. In this study the first weed stage was omitted from consideration.

Studying plant succession in relation to range management, Sampson (*10*) determined that under improper management or overgrazing vegetation and soil conditions retrogress as systematically as they originally were developed. His studies further indicate that grassland range in the climax condition furnishes abundant forage and that it withstands heavier use and has more stable soil than when it is in the lower developmental stages.

The relation of plant succession to accelerated soil erosion has been demonstrated by Forsling(*4*), who found that subalpine grassland range in central Utah in the mixed grass-and-weed stage permits 54 percent less erosion from summer rains and 57 percent less from melted snow than it does in the second weed stage. Craddock and Pearse(*3*), working in the mountains of southwestern Idaho, have determined

[1] Italic numbers in parentheses refer to Literature Cited, p. 37.

range in the climax grass stage to be capable of absorbing practically 100 percent of precipitation artificially applied, while under similar conditions grassland range in and below the second weed stage contributes an average runoff of 45.4 percent and loses 3.7 tons of soil per acre from erosion. Pearse and Woolley (*5*), also working in southwestern Idaho, demonstrated that the fibrous-rooted species characteristic of climax grassland vegetation are 2½ times as effective in getting surface water into the soil as are the taprooted plants commonly found on ranges lower in the stage of succession.

The results of the studies referred to indicate that: (1) Forage and soil values of subalpine grasslands are correlated with plant-succession stage; (2) if key plants indicative of the climax and the lower successional stages can be determined, the vegetation and soil conditions are open to field interpretation; and (3) since plants of higher or lower stages invade a plant association during progressive or retrogressive succession, indications of trend in range condition are available and furnish clues to the management practices necessary to restore and maintain the resources if the key or indicator plants are known.

Description of Subalpine Grasslands

Subalpine grasslands in Washington and in Oregon are found at or near timber line in the upper Hudsonian and lower Arctic-alpine life zones. Geographically they occur principally in the Cascade Mountains and in the higher portions of the Wallowa and Blue Mountains. They usually occupy treeless or virtually untimbered sites characterized by rugged topography, well-drained soils, an annual precipitation of 35 inches or more of which more than half occurs as winter snows, and a growing season usually limited to July and August.

Green fescue,[2] a bunchgrass peculiar to the Pacific Northwest (*16*), is the plant most characteristic of subalpine grasslands in the northern Cascades and the Wallowa Mountains (fig. 1). Generally in secondary position are subalpine and Letterman needlegrass, associated with lesser amounts of sedges and rushes, bottlebrush squirreltail, wheatgrasses, melics, bluegrasses, mountain brome, trisetums, and alpine timothy. Ross bentgrass is a common and important associate throughout the northern Cascade Mountains.

Weeds (nongrasslike herbs) characteristic of the green fescue type are Wyeth and Piper eriogonums, Nuttall gilia, lupines, Rydberg penstemon, nettleleaf gianthyssop, Oregon fleabane, western yarrow, gland cinquefoil, fescue sandwort, alpine phacelia, and pokeweed fleeceflower.

Shrubs, unimportant in the type composition, usually are represented by big sagebrush, shrubby cinquefoil, gooseberries, sticky currant, snowberries, and red mountainheath.

Subalpine grassland in the Blue Mountains is characterized by subalpine and Letterman needlegrasses. Green fescue seldom is present in appreciable amounts. With needlegrasses grow sedges, rushes, and woodrushes in important amounts and also minor quantities of grasses, such as bottlebrush squirreltail, bluegrasses, mountain brome, wheatgrasses, melics, and trisetums. Weeds commonly found in the

[2] Common and botanical names of the species mentioned in this bulletin are listed on p. 36.

Blue Mountain subalpine grasslands are pokeweed fleeceflower, Wyeth eriogonum, lupines, spreading phlox, Rydberg penstemon, sandworts, hawkweeds, western yarrow, California falsehellebore, and skunkleaf

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FIGURE 1.—A thrifty green fescue plant, exhibiting abundant seed heads and foliage.

polemonium. Shrubs, principally big sagebrush, gooseberry currant, elders, grouse whortleberry, snowberry, and red mountainheath, are present in minor quantity.

METHOD OF STUDY

The study centered on a 690-acre green fescue range in the Wallowa Mountains. The area, located in Tenderfoot Basin on the upper Imnaha River, was selected because it was known to be in a deteriorating condition and, therefore, representative of various vegetation and soil stages. An adjacent area of the green fescue type at the head of Lick Creek was selected to represent the climax condition. This area was similar to the Tenderfoot Basin except that it had been very lightly grazed for many years and had been otherwise undisturbed. Evidences of climax conditions on the Lick Creek area were the absence of accelerated erosion and the abundance and exceptional vigor of the green fescue that it supported.

Green fescue is a bunchgrass (*9*) that under optimum range conditions develops into large, closely spaced plants with extensive fibrous root systems. This growth habit gives the plant exceptional soil-binding qualities. Descriptions of deteriorated green fescue ranges are universal in mentioning a hummocked appearance due to the general occurrence of green fescue plants on soil blocks averaging from several inches to more than a foot above the general surface

level. On the assumption that the lowered soil surface between green fescue plants is an indication of soil instability and type retrogression, the data obtained on the Tenderfoot Basin area were segregated according to the relative amount of disturbed and depressed soil surface between the hummocks.

The original or climax soil condition extant on the Lick Creek area was determined as exhibiting: (1) No distinct hummocked appearance; (2) less than 25 percent of the soil surface with a tendency to erode; and (3) no accumulation of gravel or other coarse material, commonly termed "erosion pavement," on exposed soil surfaces. Soil surface on the nearby Tenderfoot Basin area was observed to have been disturbed by accelerated erosion in degrees ranging from 100 percent to somewhat less than 25 percent, with corresponding variation in the height of green fescue hummocks and in the accumulation of erosion pavement.

From these observations, five soil-condition classes by which to segregate the experimental data were set up, as follows:

A. No or virtually no evidence of accelerated erosion (or what was thought to be climax condition), 76 percent or more of the soil surface in an undisturbed condition, and no erosion pavement.

B. From 51 to 75 percent of the soil surface undisturbed, the topsoil occurring in distinct blocks or hummocks held in place by green fescue roots and extending above the surrounding ground surface; the rest of the soil surface distinctly eroded and exhibiting an erosion pavement.

C. From 26 to 50 percent of the soil surface undisturbed, the topsoil occurring in distinct blocks or hummocks; the rest of the soil surface eroded and exhibiting an erosion pavement.

D. From 1 to 25 percent of the topsoil remaining in distinct, uneroded blocks; the rest of the soil surface eroded to a pavement.

E. Less than 1 percent of the topsoil remaining uneroded; the rest of the soil surface covered with erosion pavement.

Soil and vegetation conditions on the Tenderfoot Basin area were sampled with 563 plots, each 100 square feet in area and located 3½ chains apart in a gridiron pattern. Plots were cataloged as to the soil-condition class in which they happened to fall and as to their occurrence in zones of soil removal, soil deposition, or both. Thus "r" indicated that soil was being removed from the entire plot by erosion; "d" indicated that soil was being deposited over the entire plot; and "rd" indicated that both removal and deposition were in current progress. The average height of green fescue hummocks on every plot was recorded.

Thirty-three plots on rock outcrops and 5 on talus slopes, on which erosion was considered as occurring at the normal, geologic rate, were omitted from the classification. Data from such areas, while largely eliminated from the analysis, were valuable in determining the species that are pioneers to newly formed residual soils. Six plots occurring near springs and seeps and having vegetation typical of meadows were also omitted from the foregoing classification and from the analysis, since green fescue is not typical of such moist situations. In zones of soil deposition 26 plots were omitted. In all, 493 of the 563 established Tenderfoot Basin plots were classified and their data analyzed.

Since no systematic sample plots fell on the few remnants of uneroded green fescue range in the Tenderfoot Basin, 20 plots were established at random on the nearby Lick Creek area. The data from these plots were then incorporated with data from the 493 Tenderfoot Basin plots to permit quantitative comparisons of all the recognized soil and vegetation conditions.

The average soil loss from each soil-condition class was determined from the product of the averaged heights of uneroded soil blocks retained by green fescue roots and the area of the eroded soil surface. This gave an estimate of the cubic volume of soil removed per acre from land in each condition class. Cubic volumes were converted to weight by a factor of 80 pounds per cubic foot (*15*).

Density and percent composition of vegetation were estimated by the point-observation-plot method (*13*). Average percents of density and composition of vegetation were determined for each soil condition in order to identify and describe the plant-succession stages developmental to the green fescue climax. The plant cover on the soil-condition classes B to E in this study unquestionably results from range deterioration accompanied by plant retrogression. Although certain evidences will be presented for distinguishing between retrogressive and progressive trends of succession, it is reasonable to believe that the vegetation present on the various classes is essentially that which would be present were the area in the process of building up to the climax condition under grazing use.

To develop more clearly the picture of herbage utilization, the green weight of herbage produced per 100 square feet was estimated for all species on the sample plots by the weight-estimate method (*7*) before the areas were grazed. After grazing, percent utilization estimates based on weight of herbage removed were obtained by the ocular-estimate-by-plot method (*6*) for all species occurring on the 493 Tenderfoot Basin plots. No grazing occurred, and hence no utilization estimates were made on the Lick Creek area. A quantitative measure of herbage removal was obtained by applying the percent of utilization to the herbage weight of the various species.

PLANT-SUCCESSION STAGES OF THE GREEN FESCUE TYPE

The objective in managing subalpine grasslands should be to perpetuate soil and vegetation in as near the climax condition as possible (fig. 2). Economics research has demonstrated conclusively the wisdom of maintaining climax or near-climax vegetation and soil as a means of realizing the greatest continuing returns from the land. Having the knowledge requisite to recognize and evaluate the various stages in plant succession, the range manager and user can determine whether the ranges under his supervision are in climax or near-climax condition, yielding the greatest economic return, or in a subclimax stage requiring special treatment to foster plant succession toward more satisfactory and stable forage and soil conditions. He also should recognize significant changes in plant composition as indicating an advance toward the climax or a reversal to a lower succession stage.

For convenience, the plant-succession stages to be discussed, the

experimental area involved, and the classification as to soil condition of the study plots from which the data were obtained, are summarized as follows:

	Classification
Near climax stage, green fescue-weed (Lick Creek)	A
Transition stage, mixed grass-and-weed type (Tenderfoot Basin)	B, C, D
Second weed stage, weed-needlegrass type (Tenderfoot Basin)	E

THE CLIMAX CONDITION

The vegetation of the Lick Creek area, while the best example of the green fescue climax available to the study, does not truly represent the concept of a climax condition. The ultimate in subalpine grassland succession according to Clements (*2*) is theoretically the occurrence of the climax grass species in virtually a pure stand. One of the tests of a climax grassland association, according to Weaver and Clements (*17*) is that the dominants be of the same life form; that is, grasses should not be associated with important quantities of weeds or shrubs.

The vegetation on the Lick Creek plots (class A) consists of 67.9 percent green fescue and 32.1 percent lupine (table 1). However, since these two species grow to the virtual exclusion of all others, and since the density of cover (46.7 percent) is so great as not to

TABLE 1.—*Average vegetation density*[1] *and composition of green fescue range, by soil-condition classes*

Species	Class A[2] (20 plots)		Class B (93 plots)		Class C (144 plots)		Class D (158 plots)		Class E (98 plots)	
	Density	Composition	Density	Composition	Density	Composition	Density	Composition	Density	Composition
Grasses:	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Sedges			1.8	10.4	0.7	4.8	0.7	6.9	0.3	3.8
Green fescue	31.7	67.9	3.7	21.4	3.1	21.4	1.3	12.8	.1	1.3
Bottlebrush squirreltail			.1	.6	.2	1.4	.2	2.0	.2	2.6
Subalpine needlegrass			2.4	13.9	1.5	10.3	1.1	10.9	.6	7.7
Miscellaneous			.7	4.0	.9	6.2	.3	3.0	.3	3.8
Total	31.7	67.9	8.7	50.3	6.4	44.1	3.6	35.6	1.5	19.2
Weeds:										
Western yarrow			.4	2.3	.3	2.0	.3	3.0	.1	1.3
Nettleleaf gianthyssop			.3	1.7	.5	3.4	.3	3.0	.9	11.5
Eriogonums			1.1	6.4	1.2	8.3	1.2	11.8	.9	11.5
Nuttall gilia			1.3	7.5	1.2	8.3	.9	8.9	.4	5.1
Hoary velvet lupine	15.0	32.1	2.0	11.6	1.1	7.6	.2	2.0	.6	7.7
Penstemons			.8	4.6	1.0	6.9	.4	4.0	.1	1.3
Alpine phacelia			(3)	(3)	.1	.7	.2	2.0	.2	2.6
Pokeweed fleeceflower			.1	.6	.1	.7	.2	2.0	.1	1.3
Gland cinquefoil			.4	2.3	2	1.4	.3	3.0	.1	1.3
Miscellaneous			.9	5.2	.9	6.2	1.2	11.8	1.7	21.8
Total	15.0	32.1	7.3	42.2	6.6	45.5	5.2	51.5	5.1	65.4
Shrubs:										
Big sagebrush			1.0	5.8	1.2	8.3	1.1	10.9	.8	10.3
Miscellaneous			.3	1.7	.3	2.1	.2	2.0	.4	5.1
Total			1.3	7.5	1.5	10.4	1.3	12.9	1.2	15.4
All species	46.7	100.0	17.3	100.0	14.5	100.0	10.1	100.0	7.8	100.0

[1] Density expressed in percent of ground surface covered with vegetation.
[2] Data from plots at the head of Lick Creek. All plots in B, C, D, and E were located in Tenderfoot Basin.
[3] Less than 0.05 percent.

afford favorable conditions for invasion by other species, it is probable that the vegetation of the Lick Creek plots is very close to the climax stage of development. The green fescue occurs in vigorous, closely spaced bunches that average a foot or more in diameter. It produces a spreading top growth 12 inches high or more that reduces light intensity below optimum for seedling establishment, and sends masses of fibrous roots to soil depths of 3 feet or more (*16*), thus utilizing much of the available soil misture. These facts lend weight to the conclusion that a moderate increase of green fescue on this site will eliminate the lupine and will result in the true climax condition, virtually a pure stand of the grass. For all practical purposes range having green fescue in large, vigorous bunches that dominate the vegetation to the extent of at least two-thirds the total density may be considered in climax condition.

FIGURE 2.—Green fescue range in climax condition. The stable, water-absorbent soil is more than 50 percent covered with vegetation that consists entirely of green fescue except for occasional plants of other grass and weed species.

THE SECOND WEED STAGE

Vegetation of the class E plots, consisting principally of perennial weeds with a scattering of aggressive grasses and shrubs, typifies the second weed stage. Grasses constitute 19.2 percent, weeds 65.4 percent, and shrubs 15.4 percent of the vegetation density (fig. 3). This composition (fig. 4), which differs greatly from the near-climax condition depicted by the vegetation of class A plots, is substantially the same as that described by Sampson (*10*) for the second weed stage on rather similar subalpine grassland range in central Utah.

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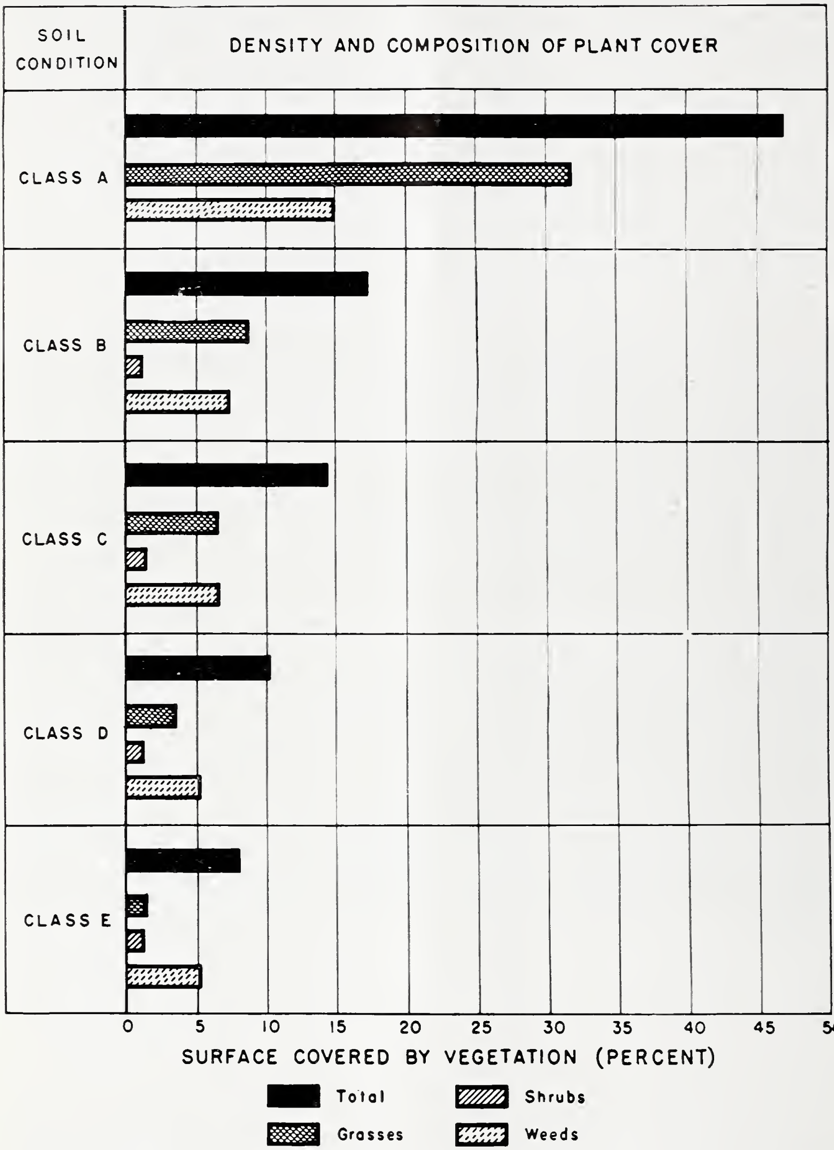

FIGURE 3.—Density and composition of plant cover by soil-condition classes.

The ground covered by all vegetation on the second weed stage (class E) plots is but 7.8 square feet per 100 (table 1), which is 83.3 percent less than on those in near-climax condition. Moreover, the density of green fescue that appears as a relict represents but 6.7 percent of the grass density and but 1.3 percent of the total plant cover on range in the second weed stage, or 99.7 percent less than on the near-climax range. Subalpine needlegrass, reported as an important subdominant of subalpine grassland vegetation in central Utah (*10*), is the most important grass, accounting for 40 percent of the grass density on class E plots. Bottlebrush squirreltail and the grasslike sedges respectively have twice and three times the density of green fescue. Chief among the weeds on plots in the second weed stage are nettleleaf gianthyssop and eriogonums that together account for 35.3

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FIGURE 4.—Green fescue range in the second weed stage of plant succession. Grasses largely have been replaced by weeds such as penstemons, gland cinquefoil, asters, and pokeweed fleeceflower. Subalpine needlegrass is most common of the grasses present.

percent of the weed density and nearly one-fourth of the total plant cover. Lupine ranks third in importance. Nuttall gilia and alpine phacelia rank fourth and fifth, respectively. Tied for sixth in importance is pokeweed fleeceflower, a perennial plant related to the knotweeds that is observed to be a prominent colonist of talus slopes and raw banks of gullies. Big sagebrush is prominent, making up two-thirds of the shrub density. Other shrubs present are gooseberry, wild currant, snowberry, and creeping mahonia, but these occur infrequently and in limited quantity.

The salient vegetation characters noted for the second weed stage of the green fescue type are:

1. A low plant density; 10 percent or less of the ground surface covered by vegetation.
2. A low proportion of grass to other vegetation; less than one-fifth of the total density accounted for by perennial grasses.

3. Green fescue, if present, occurring as a sparse, weak stand.
4. Needlegrass, associated with sedges and bottlebrush squirreltail, dominating the grasses.
5. Weeds dominating the plant association, representing more than one-half, usually two-thirds, of the total plant cover; nettleleaf gianthyssop and eriogonums prominent, pokeweed fleeceflower in evidence.
6. Shrubs present, but somewhat less prominent than grasses; big sagebrush the dominant shrub.
7. Based on general aspect, a "showy weed" type in midsummer with flowering plants lending blue, yellow, and red to the landscape, rather than the uniformly rich, lush green of the climax green fescue association.

Transition Stages

The part of the Tenderfoot Basin range intermediate between the near-climax stage (class A) and the second weed stage (class E) obviously is transitional in plant succession (fig. 5). Subalpine needlegrass, which Sampson (*10*) identifies as the species characterizing retrogression from the subalpine grassland climax in central Utah, is prominent on range in condition classes B to D, although in no in-

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FIGURE 5.—Green fescue range in the mixed grass-and-weed stage. Grasses and weeds are about in balance. Some sagebrush (upper right) is present. Green fescue is but slightly more abundant than its competitor, subalpine needlegrass.

stance does its density equal that of green fescue (table 1). The difference in density of plant cover between the various classes bespeaks more strongly the change in site productivity and signifies composition changes within the association. Vegetation density on plots in classes B to D lessens progressively from 17.3 percent to 10.1 percent. Proportion of grasses to weeds similarly lessens from 119 percent to 69 percent. Shrubs, principally big sagebrush, compose 7.5 percent of the total plant cover on class B plots, increasing to 12.9 percent on the class D plots. Green fescue is somewhat less abundant on class D than on class B plots. But the relative importance of subalpine needle-

grass and of bottlebrush squirreltail in the grass cover is somewhat greater on class D than on class B plots.

It is probable that class B most truly represents the intermediate mixed grass-and-weed stage, since there is an obviously greater gap in vegetation condition between class A and class B plots than between class B and class E. Furthermore, the species principally characterizing class E are all present in considerable quantities on class B plots, the variation between the classes being essentially a progressive reduction in proportion of grasses to weeds. Such vegetation changes as occur are useful and important in judging the trend of range condition and in applying utilization standards.

The chief vegetation characteristics of green fescue range in the mixed grass-and-weed stage are:

1. An open stand of vegetation, usually less than one-fifth of the ground surface covered by plant growth.
2. Approximately a balance between grass and weed density (fig. 5).
3. Important quantities of needlegrasses present, together with bottlebrush squirreltail and sedges; their combined densities equaling or exceeding that of green fescue.
4. The occurrence of many "showy" weeds such as lupine, western yarrow, nettleleaf glanthyssop, gland cinquefoil, eriogonum, Nuttall gilia, and penstemon.
5. Shrubs, principally big sagebrush, present in minor quantity.

RELATION OF SOIL CONDITION TO STAGE OF PLANT SUCCESSION

The outstanding feature of green fescue range in climax condition is the sodlike character of the closely spaced, dense green fescue bunches. The relatively small spaces between the grass clumps usually are not exposed soil but, rather, consist of the root crowns and root masses of dead green fescue that have yet to decompose. On the Lick Creek area this feature is so common that, in locating the perimeters of circular plots, it was frequently necessary to kick at the exposed root masses with the heel of a heavy boot in order to leave a recognizable mark. It is difficult to conceive of a more effective natural control of erosion on subalpine grassland range than is exerted by this climax type.

The most striking character of a deteriorating green fescue range is the hummocked appearance of the vegetation already described and the highly uneven ground surface (fig. 6). These blocks of original topsoil, held together by the deep, closely interwoven, fibrous roots, support most of the green fescue produced on such deteriorating range. On the lowered ground surface, several inches to more than a foot below the tops of the hummocks and littered with coarse gravelly material, is a sparse vegetation of rudimentary type, usually annuals or short-lived perennials.

The accelerated erosion evident in the appearance of erosion pavement between the live grass bunches apparently results from excessive trampling by livestock, as shown by the eroded trenches that run across the slopes as well as along them. Trampling has disintegrated the dead root masses and thereafter erosion has been augmented by the wasting away of live green fescue bunches through overgrazing, continued trampling, abrasion of the hummocked soil blocks by rapid, silt-laden runoff, and root desiccation as the moisture

level recedes with the deepening trenches. Studies on needlegrass range in southwestern Idaho indicate that trampling may double the amount of erosion under a given rainfall intensity (*3*).

Certain small, localized parts of the deteriorating range in the Tenderfoot Basin exhibit no hummocks and support a vigorous, unbroken stand of green fescue. On other virtually unhummocked areas is a sparse plant cover on soil densely littered with gravel and small rock. Here green fescue is entirely absent or is present in minor amounts, while needlegrasses, sedges, bottlebrush squirreltail, and weeds are appreciable components of the vegetation. The oc-

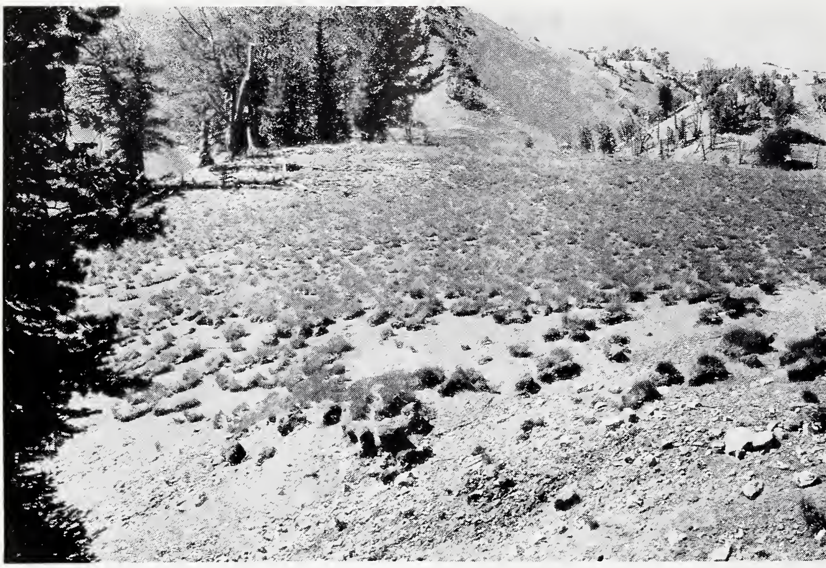

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FIGURE 6.—General view of green fescue range rapidly eroding. The deep, densely interwoven root masses of green fescue hold straight-sided blocks of topsoil intact, resulting in a pedestaled or hummocked appearance.

currence of such second-weed-stage areas might lead to the belief that the succession is progressing from barren rock outcroppings to climax plant and soil conditions, were it not for the presence of occasional hummocks that expose dead green fescue roots, remnants of the former climax vegetation, and general occurrence of the loose, silty soil overlaid with a rubble of coarse gravel that indicates serious erosion (fig. 7). It is apparent that soil removal by accelerated erosion is a major cause in the occurrence of lower successional stages of the green fescue climax.

Soil Loss by Plant-Succession Stages

Under near-climax conditions, as exemplified by the Lick Creek area, the vegetation occurs on rounded hummocks that average slightly more than an inch in height (table 2). The inconsiderable volume of soil removed from between the live plants is estimated at 1.96 tons per acre, which probably closely approximates the effect of normal geologic erosion.

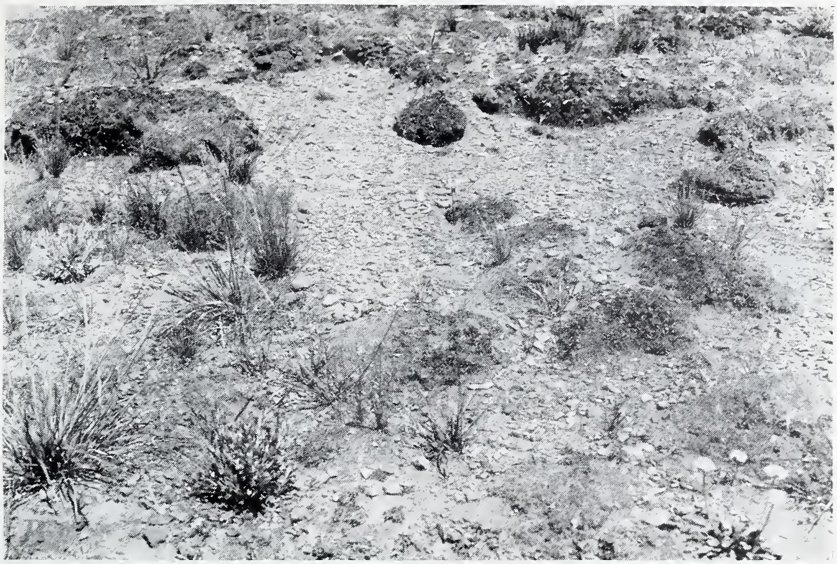

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FIGURE 7.—Range once in the green fescue type, as evidenced by the dead root hummocks, that has been eroded to a pavement and is being revegetated by big sagebrush, subalpine needlegrass, and weeds. More than 6 inches of topsoil has been eroded from this particular area.

TABLE 2.—*Soil losses from green fescue range in relation to soil-condition classes, as measured on 100-square foot plots*

Soil-condition class [1]	Plots	Surface area of eroding soil [2]	Average height of undisturbed blocks of topsoil	Volume of topsoil removed [3]	Weight of topsoil removed: Per plot [4]	Weight of topsoil removed: Per acre
	Number	*Square feet*	*Inches*	*Cubic feet*	*Pounds*	*Tons*
A	20	12.5	1.08	1.125	90.0	1.96
B(r)	14	37.5	8.14	25.438	2,035.04	443.23
B(rd)	71		6.12	9.562	764.96	166.61
Weighted average	85			12.177	974.15	212.2
C(r)	35	62.5	6.86	35.729	2,858.32	622.54
C(rd)	114		6.35	16.536	1,322.88	288.12
Weighted average	149			21.044	1,683.55	366.7
D(r)	84	87.5	6.41	47.740	3,819.20	831.82
D(rd)	69		5.23	19.068	1,525.44	332.24
Weighted average	153			34.809	2,784.76	606.5
E(r)	69	99.5	[5] 7.23	59.949	4,795.92	1,044.55
E(rd)	20		[5] 7.23	29.974	2,397.92	522.27
Weighted average	89			53.213	4,257.04	927.2
Weighted average, B to E	496	73.0		29.89	2,392.0	521.0

[1] r=topsoil being removed, no deposition; rd=removal of topsoil and deposition concurrent.
[2] Areas listed are midpoints of class intervals.
[3] Cubic-foot removal estimate of rd classes reduced 50 percent to allow for soil deposition on plots.
[4] Weight of a cubic foot of topsoil assumed to be 80 pounds.
[5] Height of soil blocks impossible to obtain by direct measure. Weighted average of heights for B(r) and C(r) used.

In contrast, the second-weed-stage range (class E) is estimated to have sustained a soil loss of 927.2 tons per acre (fig. 8), equivalent to 6.4 inches of topsoil rich in organic matter and available nitrogen. Experiments in southwestern Idaho (*3*) indicate that with not more than one-half inch of topsoil eroded (7.64 tons per acre) by a single storm, 20 percent of the nitrogen and 20 percent of the organic matter are lost from a depleted grassland range. The topsoil of eroded subalpine grassland in Utah (*11*) possesses but 32 percent of the nitrogen and 45 percent of the organic matter that is present in the topsoil of similar but noneroded range. Lime and phosphorus content of the soil on noneroded range is also slightly higher. The fertility loss that accompanies stripping of the topsoil by accelerated erosion in all probability is a major factor contributing to the lowered production of green fescue range in the second weed stage.

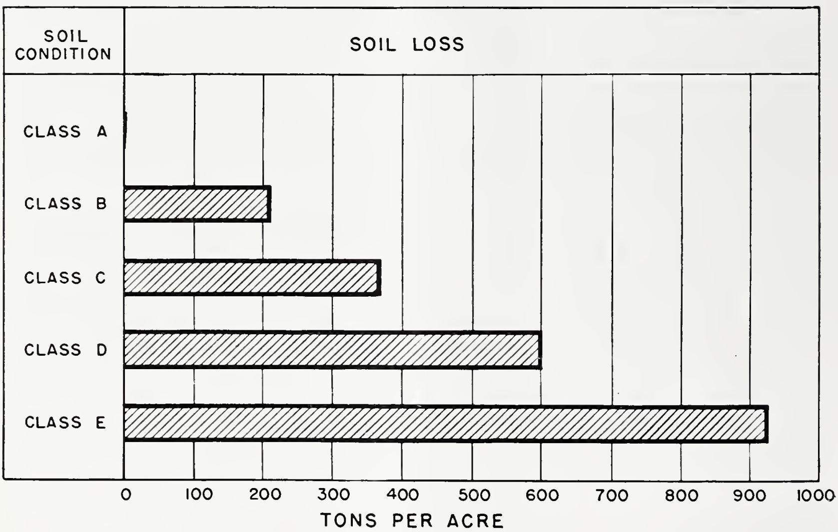

FIGURE 8.—Soil loss by soil-condition classes.

Soil losses in the mixed grass-and-weed stage of 212.2 tons, 366.7 tons, and 606.5 tons per acre, under conditions B, C, and D, would be equivalent respectively to average uniform removal of 1.5 inches, 2.5 inches, and 4.2 inches of topsoil. Removal is not uniform, however, since in condition class B nearly two-thirds of the topsoil is held intact by green fescue roots, more than one-third in class C, and slightly more than one-tenth in class D. Only on range in the second weed stage is the original topsoil so largely removed that the entire area is subjected to uniformly severe sheet erosion.

As accelerated erosion continues, however, the zone of soil removal apparently widens rather than deepens. This explains the fact that the topsoil hummocks average no higher in classes C and D than in class B (table 2). The rather constant base level results from accumulation of erosion pavement on the eroded surface, which serves partially to stabilize the soil against further rapid removal.

Change in Plant Cover Resulting From Soil Erosion

The unevenness of soil removal has considerable effect on the vegetation character of the transitional mixed grass-and-weed stage. Green fescue, for example, persists in a weakened condition on the topsoil remnants held intact by its roots, and does not disappear completely in the retrogression process, as it might if sheet erosion planed the entire soil surface to a uniform depth. Moreover, certain species—

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Figure 9.—Penstemon, gland cinquefoil, Wyeth eriogonum, subalpine needlegrass, and other second weed stage plants establish themselves on the hummocks of topsoil that have been held intact by green fescue roots. Here soil fertility and stability are more favorable than on the surrounding area of rapidly eroding soil.

notably subalpine needlegrass, Nuttall gilia, lupine, gland cinquefoil, eriogonum, western yarrow, penstemon, and big sagebrush—become established principally on the remnant soil blocks where stability and fertility are favorable for their growth (fig. 9). Soil removal between the hummocks, especially in the early stages of the retrogression, is apparently so rapid as to prevent establishment of plants incapable of succeeding on unstable soils. Exceptions are early maturing annuals such as groundsmoke and knotweed, and perennials such as nettleleaf gianthyssop, pussytoes, alpine phacelia, and pokeweed fleeceflower.

Needlegrasses and other species such as bottlebrush squirreltail, gland cinquefoil, eriogonums, and big sagebrush, which first invade the elevated soil hummocks to compete with the weakened green fescue, later colonize the eroded, somewhat stabilized soil of the C and D classes until, in the second weed stage, E class, they are spread rather uniformly over the eroded surface.

Green fescue seedlings rarely become established on rapidly eroding soils, but subalpine needlegrass and bottlebrush squirreltail come in readily on second-weed-stage areas that exhibit a moderate to heavy covering of erosion pavement. This relative lack of adaptability on

the part of green fescue is explained in part by the lower viability of the green fescue seed. Studies in the Wallowa Mountains (*9*) show green fescue seed to be 12.2 percent viable, subalpine needlegrass 27 percent, and bottlebrush squirreltail 69.5 percent. Another explanation may be that green fescue seed, being relatively large and light and awnless, is not strongly self-planting. Especially on deteriorated range, where excessive spring runoff from melted snow is to be expected from the sparsely vegetated and eroded soil surface, the chance is slight for germination of green fescue seed deposited on the soil the preceding autumn.

In contrast with the large, light, awnless green fescue seed, subalpine needlegrass seeds are fitted with apparatus that serves admirably for self-planting under adverse conditions. The stipe or callus at the base of the seed is sharp-pointed and armed with fine, stiff hairs that hold the seed in place once the point enters the soil. The planting process is aided further by the long awn which reacts to changes in moisture content, twisting when dry and straightening when wet, thereby screwing the seed into the soil (*9*). This process of self-planting takes place soon after seed dissemination in the fall and hence prior to runoff from melted snow. This phenomenon probably accounts in great measure for the aggressiveness of needlegrass in occupying eroding soils.

Bottlebrush squirreltail seed is equipped with a long, bent awn that is harsh by virtue of short, stiff hairs. The seed has not been observed to be self-planting in the manner of subalpine needlegrass seed, but it has holding qualities which, coupled with exceptional viability, enable the plant to become established and grow on unstable soils.

Thus, although accelerated runoff and erosion on the unstable subsoil between the topsoil hummocks affect green fescue seed germination and seedling establishment adversely, subalpine needlegrass and bottlebrush squirreltail can become established, if soil removal is not too rapid, and thereby aid in the soil-stabilizing process. Natural conditions are thereafter favorable for a thickening of the needlegrass stand, if soil disturbance by excessive trampling is avoided. If this trend of plant succession can be maintained, subalpine needlegrass and other vegetation must eventually contribute to soil stability and fertility to the extent that the climax green fescue again can be reestablished by natural reseeding and vegetative spread from the relict stand.

INFLUENCE OF PLANT-SUCCESSION STAGE ON WATERSHED AND GRAZING VALUES

The effectiveness with which subalpine grassland watersheds, subject to torrential summer rains and heavy winter snowfalls, perform their important function of holding up the great quantities of surface water suddenly available on stream headwaters is determined largely by the quality of plant and soil cover. Soil losses and changes in density and composition of the vegetation that accompany retrogression of the climax green fescue type determine the character of stream flow on such watersheds in respect both to height of flow peak and load of transported silt (*1*). They also affect the number of grazing animals that the range can support safely, particularly where vegeta-

tion changes consist in a decrease in species of high forage value and partial replacement by inferior forage species.

Watershed Values

The rapidity with which surface water can percolate into the ground and the amount that can be absorbed by the upper soil layers are important factors in regulating runoff. In mountainous regions, the capacity of the soil to absorb and temporarily to retain water is governed to a great extent by the general character of root system of the vegetation it supports. Plant roots so constituted that they hold the water-absorbent, upper soil layers tenaciously in place and afford a myriad of channels through which surface water may penetrate are

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Figure 10.—Sedges, principally elk sedge, that persist here and there on deteriorated green fescue range are the only plants in the second weed stage that are effective soil binders.

of great value in watershed protection. Such are the fibrous root systems of perennial grasses, the dominant vegetation of subalpine grasslands in climax condition (*5*); and of these grasses the most efficient is green fescue. Destruction of these climax fibrous-rooted plants and partial replacement by second weed-stage plants such as pokeweed fleeceflower, eriogonums, and lupines, with semitaproot systems, or groundsmoke, alpine phacelia, and pussytoes with taproots, bring about detrimental losses in soil-binding effectiveness and in percolation channels for surface water. The results are abnormal surface runoff and soil losses.

The only plants of the second weed stage of the green fescue type that approach the effectiveness of green fescue in holding the soil and aiding water percolation are the sedges (fig. 10). Subalpine needlegrass, the most abundant grass of the second weed stage, has

fibrous roots but these are relatively short and few per plant (*12*). With a loss of more than 900 tons of topsoil per acre and reversion from fibrous-rooted vegetation to a type largely composed of taprooted or semitaprooted plants, the range in this stage is poorly equipped not only for absorbing surface water but also for resisting further accelerated erosion.

Grazing Values

By virtue of its high rank in palatability, a relatively low production of green fescue may constitute most of the forage that is grazed on subalpine grassland ranges. On the Tenderfoot Basin area, for example, the weight of green fescue herbage was only 16.0 percent of the total herbage produced, yet it furnished 55.0 percent of the total herbage grazed in the type (table 3). In comparison, subalpine needlegrass and lupine produced 7.9 percent and 10.5 percent of the herbage and furnished but 9.0 percent and 1.8 percent of the forage, respectively. Utilization percents for the individual species were 44.8 for green fescue, 14.8 for subalpine needlegrass, and 2.3 for lupine.

Table 3.—*Vegetation density, weight, and utilization of various species in the green fescue type, and individual-species utilization*

Species	Average density	Composition by density	Average green weight [1]		Average green weight utilized [1]		Species utilization [2]
	Percent	*Percent*	*Grams*	*Percent*	*Grams*	*Percent*	*Percent*
Grasses and grasslike plants:							
Sedges	0.92	7.6	89.0	5.7	20.4	10.0	22.9
Green fescue	1.79	14.9	249.6	16.0	111.9	55.0	44.8
Bottlebrush squirreltail	.18	1.5	19.0	1.2	.8	.4	4.2
Subalpine needlegrass	1.26	10.4	124.4	7.9	18.4	9.1	14.8
Miscellaneous grasses	.50	4.1	61.7	3.9	3.7	1.8	6.0
Total	4.65	38.5	543.7	34.7	155.2	76.2	28.5
Weeds:							
Western yarrow	.26	2.1	22.6	1.4	1.9	.9	8.4
Nettleleaf gianthyssop	.47	3.9	92.9	5.9	6.4	3.2	6.9
Eriogonums	1.17	9.7	140.1	8.9	3.4	1.7	2.4
Nuttall gilia	.90	7.5	101.6	6.5	.2	.1	.2
Lupines	.78	6.4	164.4	10.5	3.7	1.8	2.3
Penstemons	.60	5.0	82.6	5.3	10.2	5.0	12.3
Pokeweed fleeceflower	.14	1.2	43.4	2.8	3.9	1.9	9.0
Gland cinquefoil	.23	1.9	27.1	1.7	1.7	.8	6.3
Miscellaneous weeds	1.58	13.1	132.0	8.4	16.4	8.1	12.4
Total	6.13	50.8	806.7	51.4	47.8	23.5	5.9
Shrubs:							
Big sagebrush	.98	8.1	181.5	11.6	.1	[3]	.1
Miscellaneous shrubs	.31	2.6	36.5	2.3	.6	.3	1.6
Total	1.29	10.7	218.0	13.9	.7	.3	.3
All species	12.07	100.0	1,568.4	100.0	203.7	100.0	13.0

[1] For total type.
[2] Of the total herbage of each species.
[3] Less than 0.5 percent.

Even though green fescue is present only in very small amount, livestock use it to approximately the same degree. For example, sheep utilized 44.1 percent of the fescue that had an average density of 3.7 percent on the B condition Tenderfoot Basin range. Under the same herding methods, the sheep used 46 percent of the fescue on the class E plots where its density was but 0.1 percent. The utilization of subalpine needlegrass on the same plots was 15.2 percent

and 20.5 percent respectively. However, utilization of subalpine needlegrass on a sheep range in the Blue Mountains, comparable to the Tenderfoot Basin except that no green fescue occurs, has been found to average nearly 60 percent.

In summary, it is evident not only that green fescue, as the major component of the near-climax vegetation, is of high value for grazing, but also that livestock preference for it remains essentially the same irrespective of the amount present. Furthermore, discrimination against second weed-stage needlegrass appears to be relatively constant so long as any green fescue remains. It is obvious that if the Tenderfoot Basin area should be grazed to the intensity observed on the Blue Mountain area, namely, so that more than half of the needlegrass herbage is utilized, the green fescue would be greatly overused, soil trampling intensified, and further range deterioration invited. On the other hand, moderate use of the fescue with very light utilization of the associated less-palatable species, subalpine needlegrass in particular, is doubtless essential to retard the erosion process and to allow return of climax soil and vegetation conditions. These combined attributes warrant the selection of green fescue as a species key to the grazing management of subalpine ranges on which it occurs.

Preliminary results presented later in this circular indicate that green fescue is utilized safely when 50 percent of the current herbage production is grazed, an intensity suggested also by Talbot (*14*) in discussing proper utilization of bunchgrass range in southwestern United States. On this basis, the proper-use factor of green fescue was tentatively set at 50 percent, or 11.6 percent higher than the use actually made of the species in the controlled grazing trial conducted during 1938 on the Tenderfoot Basin experimental area. The percent utilization of each associated species was uniformly raised by this proportionate amount and rounded off to the nearest 5 percent. It was also assumed that the 354 sheep-months' use made of the area in 1938 should have been greater by 11.6 percent, or a total of 395.1 sheep-months, in order to achieve proper utilization. From these data and those on species density and composition, the relative grazing capacities of the Tenderfoot Basin green fescue range in the various soil-condition classes were computed according to the procedure used with the point-observation-plot method of range survey (*8*).

Grazing capacity of near-climax green fescue range (class A) was computed as 5.35 sheep-months per acre (fig. 11). In comparison, the second weed stage (class E) averaged but 0.21 sheep-month per acre, a reduction in grazing capacity of 96 percent. The mixed grass-and-weed stage, best illustrated by soil-condition class B, showed a grazing capacity of 0.99 sheep-month per acre, 81.5 percent below the near-climax condition but 4.7 times higher than range in the second weed stage.

The differential in grazing capacity between the second weed stage and the near-climax green fescue types is so great as to warrant special comment. It is reported that previous to 1916 four bands of sheep were grazed on the Tenderfoot Basin allotment, which includes the Tenderfoot Basin experimental area, for a period of about 3 months or an equivalent of approximately 14,400 sheep-months. In 1938

about 1,200 sheep-months' grazing fully utilized the allotment. The reduction in actual use from 1916 to 1938 amounts to 92 percent, which closely approaches the estimated difference in grazing capacity between ranges in the near-climax and in the second weed stages. In further corroboration, a range survey was made in 1938 of the 2,256 acres of usable range on the Tenderfoot Basin allotment by the same crew that estimated the density and vegetation on the sample plots on the Lick Creek and Tenderfoot Basin experimental areas. The survey was made by the point-observation-plot method at an intensity of 20 sample plots per square mile (*8*). Estimated grazing capacity of the Tenderfoot Basin allotment from this survey was 983.1 sheep-months, 0.44 sheep-month per acre, or 92 percent lower than the Lick Creek near-climax vegetation.

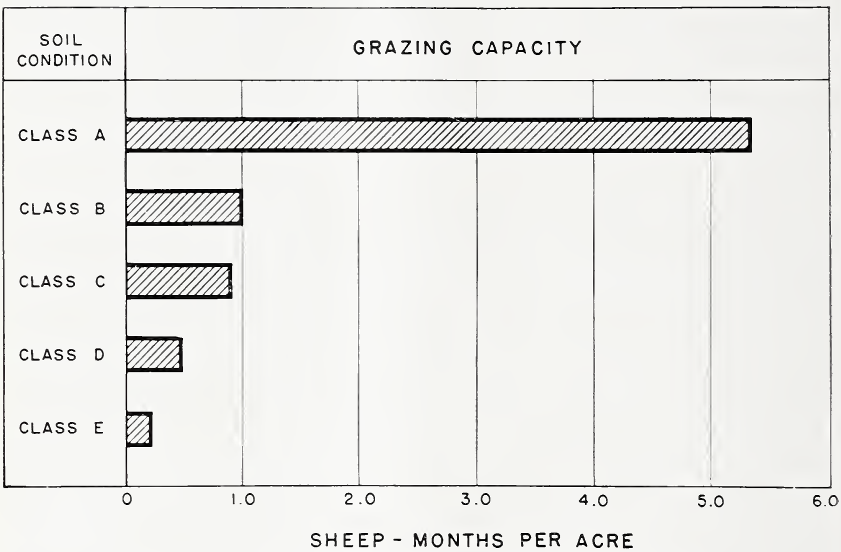

FIGURE 11.—Grazing capacity by soil-condition classes.

Based on this corroborative evidence, it can be said that retrogression of green fescue range from the near-climax to the second weed stage is accompanied by a loss of approximately nine-tenths of the potential grazing capacity. A more constructive statement is, if the near-climax range conditions can be regained, range areas such as the Tenderfoot Basin can be stocked eventually at greater intensity than they can now withstand and still be within the safety margin demanded by the proper-use objective. Aside from the benefits to be gained from restoring satisfactory watershed conditions, this is a powerful argument for careful and constructive range management. Whether the object is to maintain a range in climax or near-climax stage or whether it is to improve unsatisfactory range and watershed conditions, the management system needs the guidance of sound range-utilization standards. These standards should be designed to permit dependable field evaluation and interpretation of forage and soil conditions, the trend of conditions, and the current degree of utilization as it affects the trend.

RANGE CONDITION AS INTERPRETED FROM PLANT SUCCESSION STAGE

Many subalpine grassland ranges in the Blue and Cascade Mountains that are similar to Tenderfoot Basin in elevation, aspect, and topography contain a vegetation type largely composed of needlegrasses growing in association with sedges, big sagebrush, and weeds such as pokeweed fleeceflower, lupine, nettleleaf gianthyssop, and eriogonum. Similarities of the green fescue and the needlegrass types in topographic location, regional distribution, and species mixture suggest an ecological relationship.

In view of this possibility, vegetation on 507 100-square-foot sample plots on a 759-acre area in the Blue Mountains at the head of the North Fork of the John Day River, typifying the needlegrass type commonly found at high elevations in the Blue Mountains, was compared with the vegetation of class E plots of the Tenderfoot area as to average density and composition. The Blue Mountain sample plots were arranged 4 chains apart in grid fashion. Elevation, topography, and exposure were similar to those of Tenderfoot Basin.

The composition of the Blue Mountain plots, except for the absence of green fescue, was found to be strikingly similar to the class E plots of Tenderfoot Basin, in respect to the species that occur in mixture and to their relative abundance (table 4). Subalpine needlegrass, big sagebrush, eriogonum, lupine, penstemon, western yarrow, bottlebrush squirreltail, spreading phlox or Nuttall gilia, and sedges are of approximately equal importance on both areas. Nearly all secondary species, not shown in the tabulation, were found to occur in both situations. The only important differences are the relatively greater abundance of pokeweed fleeceflower on the Blue Mountain area and of nettleleaf gianthyssop on the class E plots in Tenderfoot Basin. Pokeweed fleeceflower is very common on loose talus slopes in Tenderfoot Basin, indicating its adaptability to loose-textured, unstable soils. The soil of the Blue Mountain area is loose, decomposed granite with a heavy surface layer of gravel and has excessive downhill creep when sheep are trailed along the slopes.

The presence of a substantial amount of subalpine needlegrass uniformly distributed on the Blue Mountain area might easily lead to the assumption that the range is in fairly satisfactory condition. The close similarity of the vegetation with that on the Tenderfoot Basin class E plots, however, clearly places this area in the second weed stage and gives evidence that present soil and vegetation conditions are far from satisfactory.

As judged from this comparison, the Blue Mountain and other subalpine grassland areas in eastern Oregon and Washington that support chiefly subalpine needlegrass and weeds portray unstable soil and vegetation conditions (fig. 12) and therefore possess grazing and watershed values much lower than the potential. Furthermore, whether the situation is brought about by misuse or whether it is the result of natural plant succession on newly formed soil, careful grazing management is essential. If the type is in a formative stage, grazing should be light in order to prevent undue slippage and erosion of loose soils. If the condition is the result of plant

and soil depletion, grazing should be managed carefully to halt further deterioration and to allow the range to recover its original productivity and watershed value.

TABLE 4.—*Comparison of a needlegrass-weed type in the Blue Mountains with the vegetation on the Tenderfoot Basin class E plots*

Species	Tenderfoot Basin class E plots		Blue Mountain needlegrass-weed plots	
	Density [1]	Composition	Density [1]	Composition
	Percent	*Percent*	*Percent*	*Percent*
Grasses:				
Sedges	0.3	3.8	0.9	9.0
Green fescue	.1	1.3		
Bottlebrush squirreltail	.2	2.6	.2	2.0
Subalpine needlegrass	.6	7.7	1.4	14.0
Miscellaneous grasses	.3	3.8	.2	2.0
Total	1.5	19.2	2.7	27.0
Weeds:				
Western yarrow	.1	1.3	.2	2.0
Nettleleaf gianthyssop	.9	11.5	(2)	(2)
Eriogonums	.9	11.5	.5	5.0
Nuttall gilia	.4	5.1		
Lupines	.6	7.7	.5	5.0
Penstemons	.1	1.3	.3	3.0
Phlox			.4	4.0
Pokeweed fleeceflower	.1	1.3	2.2	22.0
Gland cinquefoil	.1	1.3	.1	1.0
Miscellaneous weeds	1.9	24.4	2.1	21.0
Total	5.1	65.4	6.3	63.0
Shrubs:				
Big sagebrush	.8	10.3	.7	7.0
Miscellaneous shrubs	.4	5.1	.3	3.0
Total	1.2	15.4	1.0	10.0
All species	7.8	100.0	10.0	100.0

[1] Percent of ground surface covered by vegetation.
[2] Less than 0.05 percent.

CURRENT PROPER RANGE UTILIZATION

Green fescue is the plant key to the management of the green fescue type, not only because it is clearly the climax species ecologically, but also because it is highly palatable to all classes of livestock, is very nutritious, is relished throughout the grazing season even by sheep that ordinarily prefer weeds and shrubs to grass, and is an effective soil binder by virtue of its deep, dense mass of fibrous roots. For these reasons the welfare and perpetuation of the green fescue plants should govern the use of the type as a whole, and proper range utilization should be considered to have been attained only if green fescue is grazed currently to the proper degree.

Preliminary studies of grazing intensity indicate that the range is properly grazed when 50 percent of green fescue herbage is utilized. This is the maximum use that will permit maintenance of green fescue seed production and stand vigor. Analysis of the results from measuring stubble heights of more than 3,000 green fescue plants after sheep grazing (fig. 13) shows that, when an average of 50 percent of the foliage is utilized, two-thirds of the plants are grazed to a height of 3 inches or less and one-seventh of the plants remain ungrazed. Sheep grazing green fescue plants to an average

height of 3 to 5 inches have been observed to leave but few flower heads, and few if any flower heads remain on bunches grazed closer than 3 inches. With more than 50 percent of the foliage utilized, insufficient flower stalks remain to furnish seed for natural reproduction. For example, an average of 70 percent utilization of green fescue leaves only about 6 percent of the plants above 3 inches and only 1 percent ungrazed. This use intensity obviously leaves little provision for natural reseeding.

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FIGURE 12.—Typical subalpine needlegrass-pokeweed fleeceflower range in the Blue Mountains. The uniform distribution of needlegrass does not represent a satisfactory range condition but rather indicates unstable soil and low actual grazing capacity. Pokeweed fleeceflower is a reliable indicator of loose soil and depleted range.

Another reason for recommending 50 percent as the proper-use factor for green fescue is the necessity for leaving sufficient herbage following grazing to permit normal growth functions of the plant to continue. It has been noted that clipping green fescue plants to heights of 1 inch or closer greatly reduces height and vigor of foliage production the following year. Under 50 percent average use, only 3 percent of the plants are grazed to this dangerous intensity (fig. 13), whereas with 70 and 90 percent average use, 6 and 23 percent respectively are cropped to height of 1 inch or less—a condition that soon results in loss of vigor or death of an important percent of this climax grass and foreshadows type retrogression and defeat of any attempt at constructive range management.

According to the results from careful height and weight measurements of 693 green fescue plants, 50 percent removal of green fescue herbage should leave a stubble that averages 3 inches high after grazing (fig. 14). However, since livestock, especially sheep, will not graze all green fescue plants to the same degree even on very limited areas, it may be difficult to determine the average height of stubble on extensive areas. On sheep ranges, proper use can be determined

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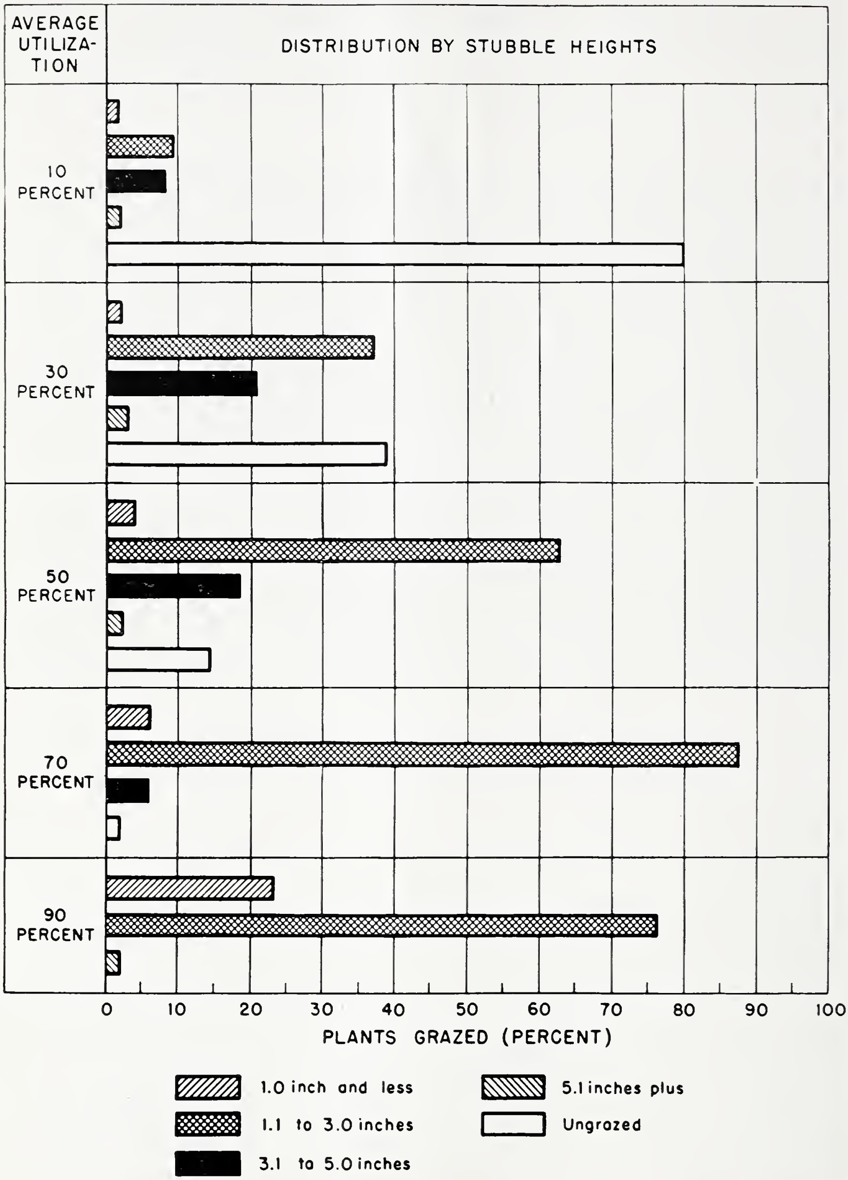

FIGURE 13.—Percent of green fescue plants grazed to various stubble heights under five degrees of utilization by sheep.

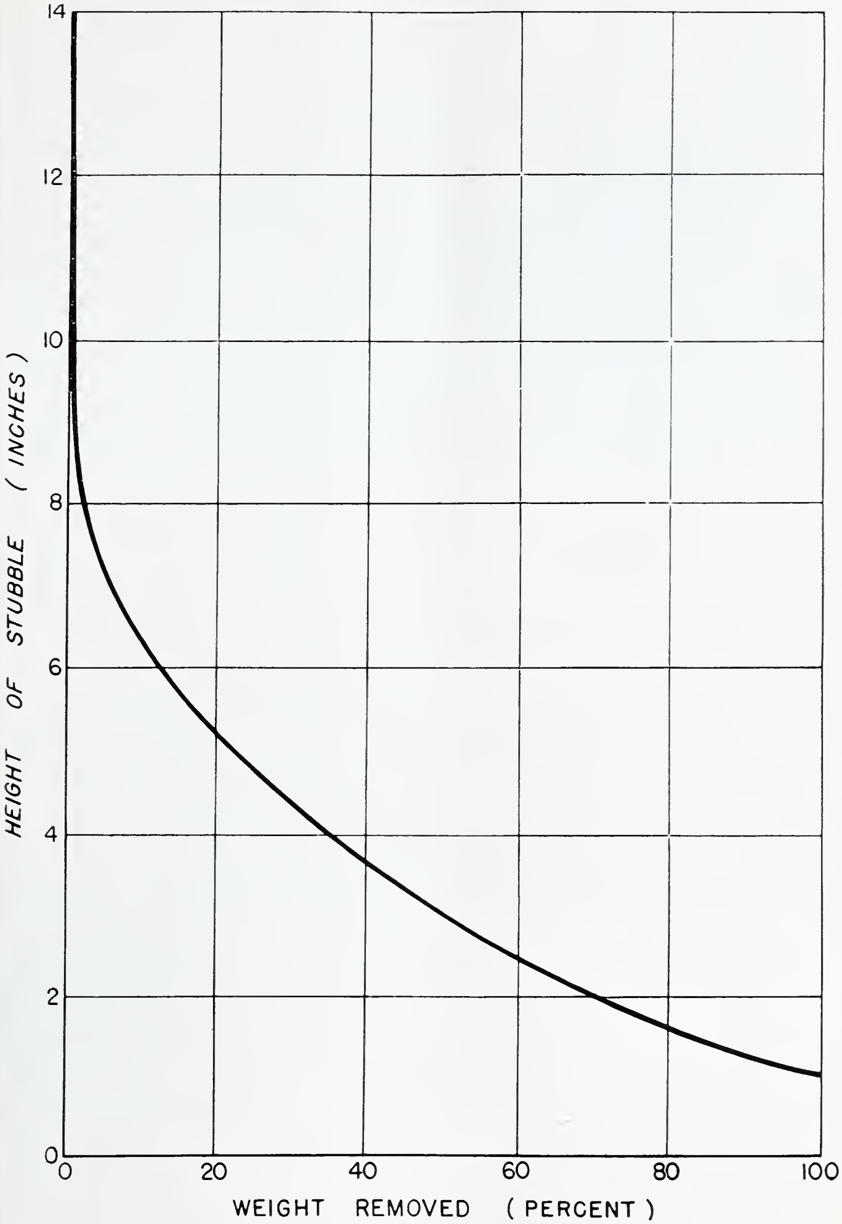

FIGURE 14.—Stubble height-utilization curve for green fescue. Stubble below 1 inch is considered as not available.

as the degree of green fescue utilization that results in very few (3 percent) plants grazed to 1 inch or less, not more than two-thirds grazed to less than 3 inches, and approximately one-seventh of the plants ungrazed (fig. 15).

No secondary grass species commonly associated with it is as palatable as green fescue. Subalpine needlegrass is utilized not more than 15 percent when green fescue is properly grazed (table 3). Some of the minor weeds, such as sweetanise, blueleaf cinquefoil, Oregon checkermallow, Scouler valerian, and pedicularis, may be utilized as much as green fescue or more, but none of the important associated weed species, such as western yarrow, nettleleaf giant-hyssop, lupine, and penstemon, is utilized as heavily at the same grazing intensity. Shrubs are used not at all, except for slight grazing of the foliage and twigs of snowberry. Therefore, range on which the density and vigor of the green fescue have been greatly reduced may be considered properly grazed when not more than 15 percent of the needlegrass herbage is taken and when the associated weeds, grasses, and shrubs, with minor exceptions, similarly are but lightly grazed.

The foregoing observations are concerned only with percent of herbage grazed. Another factor that must be taken into consideration when judging proper utilization is trampling by livestock when herbage is grazed to a specified intensity. Soils on which subalpine grassland usually occurs are so thin and loose textured and slopes are so steep that they are very susceptible to erosion as the result of undue disturbance. The palatability of green fescue is so high, however, that sheep, which ordinarily prefer weeds and shrubs to grass, will utilize 50 percent of its herbage in one grazing if they are herded in an open manner, bedded out, and undisturbed by the use of dogs or by close-herding. It follows, therefore, that these methods must be followed for proper current use of sheep range stocked within its grazing capacity and that use of dogs and the re-grazing of large areas of range must be avoided. Cattle grazing on green fescue range should similarly be well regulated by riding, salting, and fencing to prevent unequal distribution and undue congregation of animals and to permit a definite and systematic rotation of the range by units.

In some instances the soil on deteriorated green fescue range is so unstable that the danger of accelerated erosion as the result of trampling makes it inadvisable to utilize the forage to the standard of 50 percent of the current green fescue herbage production, even under the most careful livestock management. In such cases, range use must be lightened until the danger of erosion from trampling has been obviated. No set rule can be given, since the extent of corrective action must depend on the combination of such factors as the degree of slope, soil texture, kind and type of stock, and vegetation condition. Complete closure to grazing, until sufficient soil stability is regained to withstand trampling, is sometimes necessary in extreme cases.


F372015

FIGURE 15.—Range on which the green fescue herbage has been utilized 50 percent by sheep. Some seed heads remain for natural vegetation. Less than 3 percent has been grazed closer than 1 inch. The stubble averages 3 inches in height.

SUMMARY OF STANDARDS FOR JUDGING SUBALPINE RANGE

The rank that the dominant herbaceous or shrubby plants occupy in the scale of plant succession, the density of cover, the proportion of grasses to weeds and shrubs, and the extent to which soil has been disturbed by accelerated erosion, all contribute evidence of the condition of a subalpine grassland range. The apparent vigor of dominant plants, the general age and thriftiness of key ecological species and the abundance of their seedlings, and the signs of recent acceleration or retardation of erosion can be used to determine trends in range condition. The degree of use of the forage species high in the scale of plant succession, likewise, is a clue in determining whether the current grazing intensity is consistent with the management objective.

The principles and guides for judging the condition and proper utilization of subalpine grasslands that follow do not constitute a rule-of-thumb for range managers to apply mechanically in their range inspection. They provide, however, the basis for a proper approach to the utilization problems of such ranges and should result in the formulation of effective and justifiable measures to maintain and increase the forage, watershed, and recreational values through wise range management.

Recognizing Range Condition

VIRGIN CLIMAX STAGE

Subalpine grassland range that supports vegetation of the climax stage is characterized by stable, fertile soil; ample, desirable forage; and uniform, silt-free stream flow. Characteristics by which to identify established climax conditions of the green fescue type follow:

Green fescue is dominant to the degree that, on casual observation of ungrazed range, the grass appears to be growing in a pure stand, in large, vigorous bunches, and covering at least half the ground surface. The slightly purplish seed heads are conspicuous by their abundance. In midseason the soft, lush green of the dominant grass is unbroken by blue or yellow tones of flowering weeds or by the grays and browns of exposed mineral soil.

The associated vegetation, hardly to be noticed on first glance, consists of occasional plants such as needlegrasses, bottlebrush squirreltail, spike trisetum, sedges, lupine, western yarrow, penstemon, and eriogonums.

Accelerated erosion is totally absent, as evidenced by green fescue tussocks growing flush with the ground surface or on low, definitely rounded hummocks, and by the absence of erosion pavement on the small areas of exposed soil between the tussocks.

On much of the area between tussocks the soil appears tightly bound with the slowly decomposing roots of dead green fescue plants.

Stream flow is stable; there are no gullies or V-shaped drainages on steep slopes; and dense, perennial vegetation grows down to the water line of streams on gentler slopes.

RESTORED CLIMAX STAGE

Subalpine green fescue ranges depleted through poor range practices but subsequently so managed that the vegetation has essentially regained the climax stage may exhibit characteristics slightly at variance with those of the natural climax. Such areas, however, can be considered to be in satisfactory range condition. This condition of green fescue range may be identified in the following ways:

Approximately half of the ground surface is covered with vegetation, of which green fescue, growing in large, vigorous bunches, makes up two-thirds or more, and is sufficiently prevalent to subdue with its light green foliage the varied colors of associated grasses and weeds.

The secondary vegetation, consisting of relicts of species that were dominant in the lower successional stages, makes up no more than a third of the plant cover, evenly interspersed with the green fescue plants. This vegetation is the same as the secondary vegetation in the virgin climax stage except for the inclusion of melics, alpine phacelia, and big sagebrush. Secondary plants seldom if ever are found growing within the green fescue tussocks.

The exposed soil, in relatively small and discontinuous spots between green fescue plants, may exhibit an erosion pavement but is evidently stabilized by the vigorous and abundant surrounding vegetation and by young plants of perennial grass and weed species that have become established.

Any gullies or V-shaped drainages on hillsides, or channeled stream banks, are partially obscured by stabilizing plant growth that has reclaimed them.

MIXED GRASS-AND-WEED STAGE

Subalpine grassland ranges that support vegetation of the mixed grass-and-weed stage, or of the lower second weed stage, are in poor condition, since they are producing less than the maximum amount of forage and their watershed properties have been impaired. Green fescue ranges in the mixed grass-and-weed stage are recognized as having the following characteristics:

An open stand of vegetation rarely covers more than one-third of the ground surface. Brown and gray tones of patches of exposed soil are discernible from a distance.

Competition of subclimax grasses, notably subalpine needlegrass, is very evident, these grasses making up about half of the grass cover and usually less than one-fourth of all the vegetation.

The midsummer landscape is one of bright colors intermixed with green because the conspicuous flowers of such weeds as penstemon, lupine, western yarrow, nettleleaf gianthyssop, gland cinquefoil, alpine phacelia, Columbia groundsel, and eriogonums grow in nearly equal proportion with grasses.

Weeds, subclimax grasses, and sedges are growing on green fescue hummocks, an invasion made possible by thinned fescue foliage or by recent mortality of the fescue plants.

Pussytoes, fescue sandwort, alpine phacelia, and other ruderal weeds appear commonly on exposed mineral soil.

Big sagebrush is present as an occasional plant, but not prominent in the vegetation complex.

Accelerated erosion is more or less conspicuous in the noticeable accumulation of erosion pavement on exposed soil surfaces, the occasional occurrence of sidehill gullies and V-shaped drainage channels, and a tendency for green fescue tussocks to be pedestaled somewhat above the general ground surface.

SECOND WEED STAGE

Characteristics of green fescue range in the second weed stage are as follows:

The stand of vegetation in general is extremely open, usually covering less than 10 percent of the ground surface. Browns and grays of exposed mineral soil are plainly visible through the short, sparse plant cover.

Green fescue is represented by remnant plants the foliage of which usually constitutes less than one-tenth of the grass cover and less than one-twentieth of the total vegetation; these are usually on elevated soil pedestals, or are fugitive plants, sheltered by individuals of less palatable species, such as sagebrush, lupine, or sedges.

The former abundance of green fescue is sometimes indicated by the presence of remnant dead plants on soil pedestals.

Grasses, as a class, usually constitute less than one-fourth of the total plant cover. The main grass species usually are needlegrasses, bottlebrush squirreltail, sedges, melics, and big mountain brome. Needlegrasses sometimes occur in virtually pure stands of considerable area (fig. 16).

Weeds, such as nettleleaf gianthyssop, phlox, lupine, eriogonum, penstemon, pokeweed fleeceflower, western yarrow, Columbia groundsel, asters, and fleabanes represent as much as two-thirds of the plant cover and at flowering time lend a kaleidoscopic color to the landscape in which green tones are outweighed by shades of blue, white, yellow, and red.

Shrubs, mainly big sagebrush, are a conspicuous part of the cover, sometimes occurring in rather dense patches on ridge tops and hillsides.

The surface soil shows unmistakable evidence of having been eroded; a heavy accumulation of erosion pavement, nearby streams flowing in distinctly cut channels, and hillside drainages with deep, V-shaped gullies are of common occurrence.

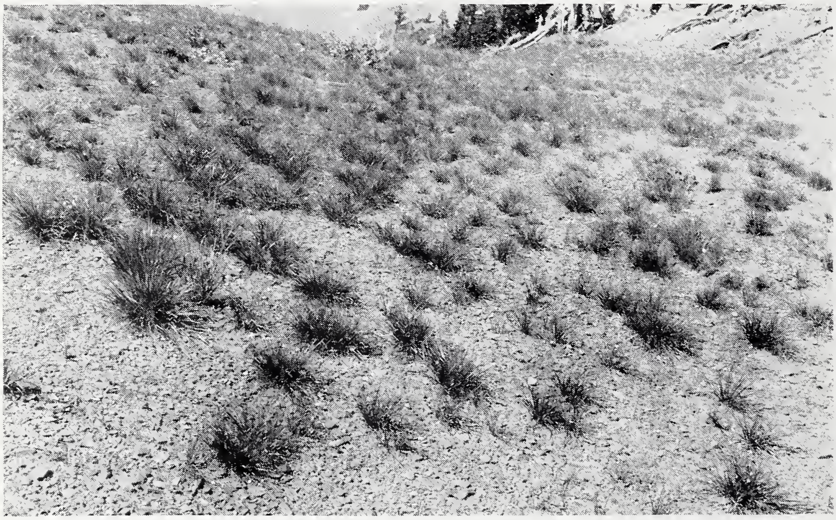

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FIGURE 16.—Subalpine needlegrass sometimes grows in virtually pure stands on depleted green fescue range, indicating the second weed stage of plant succession, further evidenced by the prevalence of erosion pavement, the occasional presence of such weeds as pokeweed fleeceflower that are pioneers in invading newly formed soil, and the dead remnants of hummocked green fescue.

RECOGNIZING TREND IN RANGE CONDITIONS

Improvement or deterioration in range condition usually can be recognized by noting the vigor of the main forage species, the species being seeded naturally and becoming established, and the acceleration or retardation of soil erosion. An upward trend in the condition of green fescue range is indicated as follows:

Accelerated erosion has been arrested, as evidenced by (1) perennial vegetation established on eroded banks of drainage channels, and on the sides and bottoms of gullies; (2) absence of exposed roots of green fescue and sedges, particularly on steep slopes; (3) soil pedestals with sloping rather than vertical sides; (4) root crowns of perennial grasses and weeds not partially buried with silt deposits; (5) absence of newly deposited silt and debris on the uphill side of soil pedestals, sticks, stones, and other obstructions to downhill soil movement.

Green fescue plants are noticeably of strong vigor, of a lush green, with dense, thrifty foliage and numerous seed heads.

Exposed mineral soil is at least sparsely colonized with seedlings and young plants of perennial species. Where mature green fescue plants are plentiful, seedlings of that species should be common, whereas if relict green fescue plants are sparse, an improvement in range condition may be indicated by a reasonably heavy stand of seedlings and young plants of subalpine needlegrass, sedge, and bottlebrush squirreltail between green fescue tussocks. On the other hand, if subalpine needlegrass and other secondary species are vigorously invading weakened green fescue tussocks as well as areas of bare soil, the range condition is not improving.

The following are early symptoms of retrogression from the climax green fescue stage:

Green fescue plants are generally low in vigor and have an unhealthy appearance. Young, thrifty plants of aggressive perennial weeds such as lupine, western yarrow, and penstemons are prominent.

Close inspection shows young plants and seedlings of needlegrasses and bottlebrush squirreltail to be abundant. If these are growing on

F371989

Figure 17.—An illustration of green fescue low in vigor. The leaves are short, seed heads are sparse, and the plants are small in comparison with exposed root masses.

hummocks with weakened green fescue plants, the evidence is particularly significant.

Accelerated erosion has started, as evidenced by (1) visible networks of contour stock trails and shallow water channels that noticeably divide the green fescue "sod" into islands; (2) common occurrence of green fescue on low but straight-sided hummocks; (3) erosion pavement noticeable; (4) occasional partially denuded patches, with signs of local gullying and sheet erosion.

Indications of continued deterioration of green fescue range in and below the mixed grass-and-weed stage are these:

Vigor is noticeably lacking in green fescue plants (fig. 17), as evidenced by a scarcity of seed heads; short herbage (usually less than 8 inches); and thin herbage with large root masses supporting small, scattered plants and dead roots plainly visible through the foliage.

Weeds, such as lupine, western yarrow, eriogonum, Nuttall gilia, and pokeweed fleeceflower, show an increase both in the abundance and thriftiness of mature plants and in number of well-established seedlings.

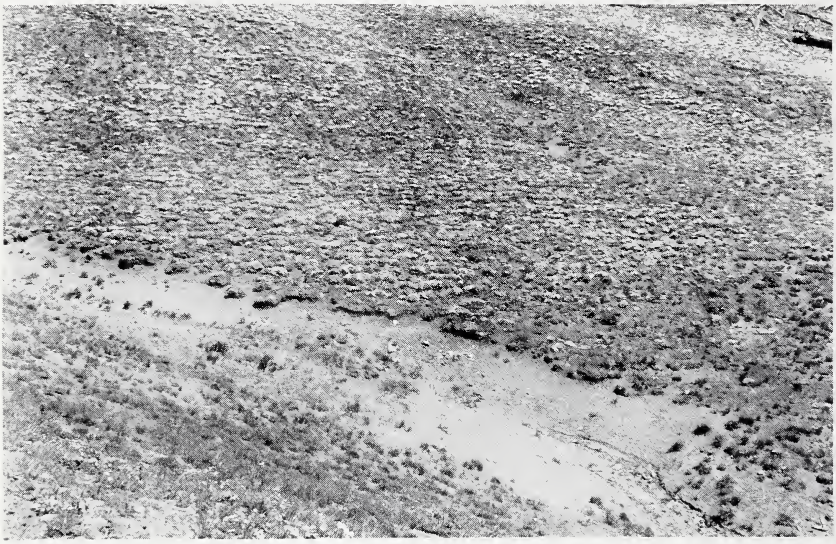

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FIGURE 18.—Conspicuous evidences of accelerated erosion on green fescue range are green fescue plants on distinct soil pedestals, V-shaped hillside gullies devoid of vegetation, and contour trenches on sidehills caused by livestock trailing.

Mature weed plants and seedlings, as well as thrifty subalpine needlegrass and bottlebrush squirreltail, are growing conspicuously both on and between green fescue tussocks.

Young big sagebrush plants and big sagebrush seedlings are present, sometimes in abundance.

Pokeweed fleeceflower, a species that denotes unstable soil, grows between the green fescue tussocks.

Accelerated soil erosion is in progress (fig. 18), as evidenced by (1) water channels and stock trails between plants and plant remnants (2) green fescue plants on straight-sided soil pedestals, with roots plainly exposed; (3) loose clods of topsoil still held intact by dead green fescue roots (fig. 19); (4) fresh deposits of silt and debris on upper side of soil pedestals, sticks, rocks, and other obstructions to downward soil movement; (5) root crowns of plants growing at the foot of slopes partially buried by deposited silt and debris; (6) extensive areas of erosion pavement evident; (7) shoestring gullies at heads of drainage courses; (8) sidehill drainage

in definite gullies with bare, steep sides, and sparsely vegetated. V-shaped stream channels; (9) contour trenches on sidehills caused by livestock trailing.

Use of Green Fescue Key to Management

Green fescue is considered to be the key plant in management of the green fescue type of the subalpine grasslands of eastern Oregon and Washington and as such should be fostered by the management system.

Green fescue range is considered to be properly used when not more than 50 percent of the green fescue herbage is grazed currently. This should leave a stubble averaging 3 inches high, in which only about 3 percent of the plants are grazed to 1 inch, not more than two-thirds to 3 inches, and almost one-seventh are ungrazed.

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Figure 19.—Loose clods of topsoil held together with dead green fescue roots are unmistakable evidence that accelerated erosion is still in progress.

Fifty percent use of green fescue is proper, however, only if livestock are carefully handled, since soil disturbance from trampling is apparently as detrimental to this range type as overutilization of herbage. If the soil is notably unstable, use of green fescue should be lighter than 50 percent to guard against soil disturbance. Closure to grazing until soil conditions improve is advisable in extreme cases.

LIST OF COMMON AND BOTANICAL NAMES OF SPECIES MENTIONED

Grasses and grasslike plants:

Bentgrass, Ross	*Agrostis rossae*
Bluegrasses	*Poa* spp.
Brome, mountain	*Bromus carinatus*
Fescue, green	*Festuca viridula*
Melics	*Melica* spp.
Needlegrass, Letterman	*Stipa lettermani*
Needlegrass, subalpine	*S. columbiana*
Rushes	*Juncus* spp.
Sedge, elk	*Carex geyeri*
Squirreltail, bottlebrush	*Sitanion hystrix*
Timothy, alpine	*Phleum alpinum*
Trisetum, spike	*Trisetum spicatum*
Wheatgrasses	*Agropyron* spp.
Woodrushes	*Luzula* spp.

Weeds:

Checkermallow, Oregon	*Sidalcea oregana*
Cinquefoil, blueleaf	*Potentilla glaucophylla*
Cinquefoil, gland	*P. glandulosa*
Eriogonum, Piper	*Eriogonum piperi*
Eriogonum, Wyeth	*E. heracleoides*
Falsehellebore, California	*Veratrum californicum*
Fleabane, Oregon	*Erigeron speciosus*
Fleeceflower, pokeweed	*Polygonum phytolaccaefolium*
Gianthyssop, nettleleaf	*Agastache urticifolia*
Gilia, Nuttall	*Gilia nuttallii*
Groundsel, Columbia	*Senecio columbianus*
Groundsmoke	*Gayophytum* spp.
Hawkweeds	*Hieracium* spp.
Knotweeds	*Polygonum* spp.
Lupine, hoary velvet	*Lupinus leucophyllus canescens*
Pedicularis	*Pedicularis* spp.
Penstemon, Rydberg	*Penstemon rydbergii*
Phacelia, alpine	*Phacelia alpina*
Phlox, spreading	*Phlox diffusa*
Polemonium, skunkleaf	*Polemonium pulcherrimum*
Pussytoes	*Antennaria* spp.
Sandwort, fescue	*Arenaria formosa*
Sweetanise	*Osmorhiza occidentalis*
Valerian, Scouler	*Valeriana scouleri*
Yarrow, western	*Achillea lanulosa*

Shrubs:

Cinquefoil, bush	*Potentilla fruticosa*
Currant, gooseberry	*Ribes montigenum*
Currant, sticky	*R. viscosissimum*
Elders	*Sambucus* spp.
Gooseberries	*Ribes* spp.
Mahonia, creeping	*Mahonia repens*
Mountainheath, red	*Phyllodoce empetriformis*
Sagebrush, big	*Artemisia tridentata*
Snowberries	*Symphoricarpos* spp.
Whortleberry, grouse	*Vaccinium scoparium*

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U. S. GOVERNMENT PRINTING OFFICE: 1942